SCIENTIFIC AGRICULTURE

Volume 24 APRIL, 1944 No. 8

STUDIES IN SEED POTATO TREATMENTS

III. AGENCIES AND PRACTICES THAT REDUCE THE STRENGTH OF MERCURIC CHLORIDE SOLUTIONS, CAUSING INEFFECTIVE DISINFECTION[1]

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[Received for publication February 22, 1944]

The recent publications of studies I and II dealt with methods for testing and adjusting corrosive sublimate solutions (2, 3). The succeeding paper (4) concerns the repeated use of corrosive sublimate solutions by means of strength-control and by acidulation with acetic acid. Some of the experiments of this paper were completed before the above published methods were developed. The original investigation has been expanded to include a systematic study of the indiscriminate and common practices of farmers in treating procedures, with the ultimate purpose of recommending, if possible, a definite procedure by eliminating the offending agencies.

The authors have confirmed the results of Weimer's systematic investigation (10). Weimer and others (6, 9, 10, 11) concluded that a general procedure of treatment was impossible and unreliable, because of the type and quantity of soil, refuse, sacks, etc. which may accompany the potatoes into the solution, but that some definite method was needed to meet the individual farmer's requirement.

The most commonly used seed potato disinfection in Canada is the standard long soak for $1\frac{1}{2}$ hours in 1: 1000 mercuric chloride solution. Accordingly, this treatment was employed to ascertain the losses of mercuric chloride effected by washed potatoes, different types of treating vessels, sacks and soils. The possible effects of well waters (6) and of the reducing substances in the potato tuber (5, 8) are also considered. In preparing the disinfection solutions, the common error of attempting to dissolve the mercuric chloride crystals in cold water, was eliminated by the use of a 5% "stock" solution, prepared with hot water (3).

Methods of Analysis

In Table 1, mercuric chloride was determined as the sulphide (1), but in subsequent experiments, by the authors' laboratory method (2), and/or by Jamieson's volumetric method (7) as noted in the tables, Jamieson's being considered as the standard and more reliable for general mercury

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analyses. For the experiments with sacks and soils, the authors' method was not always applicable, due to the highly reducing substances present in some sack and soil solutions, but when these reducing substances were excluded, the method was found simple, quick and sufficiently accurate.

LOSSES OF MERCURIC CHLORIDE

Reduction Effected by Treatment Vessel

Solutions of determined strengths were allowed to stand in galvanized iron, wooden and glass vessels for various periods of time, Tables 1, 2 and 3. The mercuric chloride was determined as gram per 1000 ml. solution before and after the period of treatment.

TABLE 1.—REDUCTION BY GALVANIZED IRON VESSELS

Reduction period	Vessel No. 1		Vessel No. 2	
	$HgCl_2$ per litre	Reduction	$HgCl_2$ per litre	Reduction
	gm.	%	gm.	%
At start	.491		.487	
1 hour	.344	29.9	.347	28.8
5 hours	.230	53.2	.235	51.8
24 hours	.041	91.7	.048	90.2

It is not likely that metal vessels are being used these days, but the rapid loss of mercuric chloride, shown in Table 1, serves to give some idea of the effect of nails and wire of crates and hampers, which are used as containers of potatoes in treating practices.

TABLE 2.—REDUCTION EFFECTED BY WOODEN PAIL

Reduction period	$HgCl_2$/1000 ml. solution*		Reduction		Remarks
	Start	Finish	Total	1½ hr. rate	
	gm.	gm.	%	%	
1½ hours	.955	.919	3.8	3.8	Scrubbed—no previous treatment
17½ hours	.891	.750	15.8	1.4	After 2 batch treatments
16 hours	.966	.884	8.5	.8	After 4 batch treatments
90 hours	.996	.708	28.9	.5	After 7 batch treatments
1½ hours	1.006	1.006	None		After 7 batch treatments
24 days	.974	.893	8.3	.02	After 9 batch treatments

* Determined by the authors' laboratory method.

The wooden pail was about 10-litre capacity, in which 5 litres of solution, prepared from tap water and 5% "stock", were used. The loss of mercuric chloride for the first 1½ hours was 3.8% (Table 2). It may be considered economical to allow solutions to stand overnight in wooden vessels for adjustment and use the next day; the over-night loss was 15.8%

after 2-batch treatments but only 8.5% after 4 treatments. After 9 treatments had been made when the vessel had become well seasoned with mercuric chloride, the total loss of mercuric chloride in the solution, standing for 24 days was 8.3%. The loss rate per 1½ hour diminished from 3.8% at the start to 0.02% after 24 days.

TABLE 3.—REDUCTION EFFECTED BY GLASS VESSEL

Reduction period	$HgCl_2$/1000 ml. solution*		Reduction	Remarks
	Start	Finish		
	gm.	gm.	%	
14 hours	.895	.898	None	After 4 batch treatments
16 hours	.847	.855	None	After 5 batch treatments
8 days	.923	.934	None	After 8 batch treatments

* Determined by the authors' laboratory method (2).

No loss of mercuric chloride occurred in the glass vessel (Table 3). Tap water, likewise, had no reducing effect and, consequently, it would appear that any good drinking water can be safely used to prepare treating solutions.

Reduction Effected by Washed Potatoes

The potatoes were washed by soaking in water 5 to 10 hours. Eight- to nine-pound lots of the seed, a mixture of varieties and sizes, 1½ to 12 ounces, were immersed in 5 litres of mercuric chloride solution for 1½ hours. The strength of the solutions was determined by the laboratory method of the authors (2) before and after the treatment. The results are shown in Table 4.

TABLE 4.—REDUCTION EFFECTED BY WASHED POTATOES IN GLASS VESSEL

Successive treatments	$HgCl_2$/1000 ml. Solution		Reduction
	Start	Finish	
	gm.	gm.	%
1st lot	.990	.930	6.1
2nd lot	.942	.869	7.7
3rd lot	.961	.924	3.9
4th lot	.946	.895	5.4
5th lot	.963	.911	5.4
6th lot	1.005	.950	4.5
7th lot	1.018	.985	3.2
8th lot	1.081	.962	11.1
9th lot	1.009	.974	3.5
9 treatments averaged			5.6

The solution was made up fresh for the first lot and mercuric chloride 5% "stock" and water were added before each subsequent lot treatment. The loss of mercuric chloride varied from 3.2 to 11.1% per treatment,

averaging 5.6% for 9 batches. Cut tubers and the size of tubers probably account for most of the variation; the presence of some soil or broken sprouts, in spite of the tubers being washed, may also have had some effect.

Reduction Effected by Sacks

Empty soiled sacks, of 100-lb. capacity, which had been used for various purposes before containing potatoes, were lightly shaken before treatment. Each sack was immersed and thoroughly wetted in 5 litres of carefully prepared 1 : 1000 mercuric chloride solution in a glass vessel and allowed to remain for 1½ hours. Excess solution was lightly pressed out as the sack was removed and the mercuric chloride determined in the resultant solution.

TABLE 5.—REDUCTION EFFECTED BY DIRTY USED SACKS

	Gunny sacks		Grain sack	Sugar sack
	No. 1	No. 2		
Start ($HgCl_2$ per litre)	1.000	1.000	1.000	1.000
Finish*	.553	.609	.650	.849
% reduction	44.7	39.1	35.0	15.1
Finish† ($HgCl_2$ per litre)	‡	‡	‡	.851
% reduction				14.9

* Determined by Jamieson's volumetric method.
† Determined by authors' laboratory method.
‡ Not determinable by authors' laboratory method.

The strength of mercuric chloride solutions may be reduced by 15% from sugar sacks to as much as 45% from gunny sacks in 1½ hours (Table 5). The sugar sack-solution was the only one determinable by the authors' method (2). Two of the sack-solutions were titrated with standard permanganate solution: aliquots of 100 ml. solutions from gunny sack No. 2 and grain sack reduced 7.45 ml. and 1.70 ml. 0.1 N potassium permanganate, respectively, corresponding to 39.1% and 35% reduction of mercuric chloride. Tap water, which was used for all treatment solutions in this paper, had no reducing effect on 0.1 N permanganate solution.

The reducing effect of gunny sack No. 1 and the sugar sack, after being washed well, dried and retreated in fresh solution for 1½ hours is shown in Table 6.

TABLE 6.—REDUCTION EFFECTED BY WASHED SACKS

	Gunny sack No. 1		Sugar sack	
Start ($HgCl_2$ per litre)	1.000		1.000	
Finish ($HgCl_2$ per litre)	.723*	.729†	.940*	.926†
Percentage reduction	27.7	27.1	6.0	7.4

* Determined by Jamieson's volumetric method.
† Determined by the authors' laboratory method.

From Tables 5 and 6, gunny sack No. 1 effected 44.7% loss of mercuric chloride before being washed compared to 27.7% after being washed, and the sugar sack effected 15.1% loss before compared to 6.0% loss after. The effect of sacks in reducing the strength of mercuric chloride solutions is probably both chemical and physical in nature, the latter effect possibly adsorption of mercuric ions on the fibre surfaces of the sacks; the applicability of the authors' method for determining mercuric chloride (Tables 5 and 6) supports this conclusion.

Another factor, not appearing in Tables 5 and 6, is the removal of solution by sacks after each treatment. When potatoes are immersed in sack containers, water and stock mercuric chloride must be added to restore the volume and strength of the solution for the next batch.

TABLE 7.—SOLUTION REMOVED BY SACKS

	Gunny sack No.1	Grain sack	Sugar sack
Allowed to drip	710 ml.		300 ml.
Percentage of original volume	14.2		6.0
After being "wrung out"	595 ml.	400 ml.	200 ml.
Percentage of original volume	11.9	8.0	4.0

Table 7 shows the amounts of solution removed by sacks from 5 litres of 1 : 1000 solution of mercuric chloride. This removal of solution by sacks, therefore involves losses of mercuric chloride which are additional to the losses shown in tables 5 and 6.

The Reduction Effected by Soils

The soil samples were representative of three types from which potatoes had been harvested. The sample of sweepings was obtained from a warehouse floor. The sandy soil contained less organic and vegetable matter than the other samples. One pound of each sample was stirred into 5 litres of carefully prepared 1 : 1000 solutions of mercuric chloride in a glass vessel and allowed to stand for $1\frac{1}{2}$ hours.

TABLE 8.—REDUCTION EFFECTED BY SOILS

	Sandy		Sweepings		Clay loam		Sandy loam	
Start ($HgCl_2$ per litre)	1.000		1.000		1.000		1.000	
Finish ($HgCl_2$ per litre)	.889*	.877†	.769*	‡	.735*	‡	.707*	.693†
Percentage reduction	11.1	12.3	23.1		26.5		29.3	30.7

* Determined by Jamieson's volumetric method.
† Determined by authors' laboratory method.
‡ Not determinable by authors' laboratory method.

According to Table 8, the strength of mercuric chloride solutions was reduced considerably by soils, varying from 11.1% for sand to 29.3% for sandy loam. The presence of the highly adsorbent substances, viz., the

straw and vegetable matter in the sweepings and the colloidal particles in the clay loam, is significant. Consequently, in the solutions containing the sweepings and the clay loam, where the authors' method was not applicable, it is possible that physical adsorption predominated to reduce the strength of mercuric chloride; in the solutions containing the sandy loam and the sandy soils, the loss of mercuric chloride may have resulted more from chemical reduction than from physical adsorption.

CONCLUSIONS

For the standard long soak treatment, it appears conclusive that sacks, crates or hampers, soils and unsuitable treatment vessels with metal contacts with the solution rapidly render mercuric chloride solutions useless for seed potato disinfection. The rapid loss of mercuric chloride in disinfection processes may be due both to chemical reduction and physical adsorption. Well waters of good drinking quality (Table 3) and the reducing substances of the potato tuber (5, 8), if cut tubers be discarded for seed, may be considered as negligible reducing factors, compared to sacks, soils, etc.

In order to ensure effective disinfection by the long soak treatment of successive lots of potatoes by the repeated use of the original solution, it is necessary to exclude the reducing agencies from the process, and to maintain a strength-control of the mercuric chloride solution. The following procedure is recommended:

(1) Use concrete, porcelain, or wooden treating vessels, free from metal contacts with the solution.

(2) Do not treat potatoes in sacks, or in crates and hampers held together by nails and wire.

(3) Remove as much soil and vegetable matter as possible from the tubers, preferably by soaking in water, before treating.

(4) Test and adjust the strength of mercuric chloride solutions before treating successive lots of tubers according to the easy and effective control methods of the authors (2, 3).

SUMMARY

The loss of mercuric chloride during seed potato disinfection is possibly due to both chemical reduction and physical adsorption: the actual losses effected, in 1½ hours from 5 litres of 1 : 1000 solution, by various agencies were 15 to 45% by dirty used sacks; 6 to 28% by washed sacks; 11 to 30% by 1 pound of soils; 3 to 11% (average 5.6%) by washed potatoes; 0.5 to 3.8% by wooden vessels. Potato tubers have a negligible reducing effect, if the cut tubers be discarded for seed treatment. Any well water of drinking quality can be used to prepare the solutions.

The repeated use of the original solution for effective disinfection by the standard long soak process is possible by excluding the reducing agencies and by maintaining strength-control as follows: (1) Remove as much soil and refuse as possible from the tubers, preferably by soaking in

water for 3 hours or more; (2) Use concrete, porcelain, or wooden treatment vessels, free from metal contacts with the solution; (3) Discontinue the use of sacks and other potato containers, such as crates and hampers, held together by nails and wire, for immersing the tubers in the mercury solutions; (4) Test and adjust the strength of the mercuric chloride solution before each successive treatment by the authors' methods.

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STUDIES IN SEED POTATO TREATMENTS

IV. THE REPEATED USE OF CORROSIVE SUBLIMATE SOLUTIONS BY STRENGTH-CONTROL AND BY ACIDULATION WITH ACETIC ACID FOR EFFECTIVE DISINFECTION PRACTICE[1]

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[Received for publication February 22, 1944]

In the preceding study of this series (6), the authors showed the nature and the extent of the losses of mercuric chloride, which may occur in the practice of the long soak disinfection. Earlier studies, I and II (4, 5), dealt with methods for testing and adjusting corrosive sublimate solutions. The present and concluding study concerns the numerous advantages of disinfection with acidulated corrosive sublimate solutions compared to the "standard long soak" with strength-control.

The long soak disinfection has been generally accepted as the standard and most effective control of potato tuber-borne diseases. The process, consisting of a 90-minute soak in 1 : 1000 mercuric chloride solution, viz., 4 ounces per 25 imperial gallons, has always been handicapped by the rapid loss of mercuric chloride. In practice, it has been customary to add $\frac{1}{2}$ to 1 ounce of corrosive sublimate per 25 gallons solution, after each treatment in order to replenish the solution for the next batch and to discard the solution after 3 to 6 lot treatments (1, 2, 9, 11). This indefinite procedure was found unreliable[4] and entirely too expensive at the present costs of labour and materials (9).

Doubtless, more growers would disinfect their seed potatoes if less time were required. Nevertheless, the hot corrosive sublimate treatment (1, 2, 11), requiring only 2 minutes at 126° F. although effective, has never been popular. However, the acidulated mercuric chloride treatment (2, 3, 8, 9, 11) possesses merits which would seem to warrant its popular adoption. Acidulation prevented the usual rapid loss of mercuric chloride and afforded a high control of tuber-born diseases in as short a time as 5 minutes. Plummer and Bonde (9) preferred acidulation with acetic acid, which, they showed, was as effective as hydrochloric and was less injurious to tubers, human skin and clothing; 89% of rhizoctonia was controlled in 5 minutes; the original treating solution was used for 25 succesive lots of unwashed tubers without the need of any adjustment; the tubers were treated by hand in a porcelain vessel; the efficiency of the solution was not decreased when the time of treatment was increased to 10 minutes or longer.

To the farmer, the ultimate potato yield is the criterion of successful seed disinfection. Occasionally, when the seed has been planted immediately after being treated, especially in a dry season, decreased yields

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have resulted from disinfected-diseased-seed (2, 10, 12). The dormancy of seed, induced by disinfection, postpones the resprouting of the tubers and, when planted immediately, may delay the early growth by 2 to 3 weeks and accordingly adversely affect the yield. Consequently, in order to ensure substantially increased yields, seed should be treated preferably in the fall or winter or 30 days before planting in the spring. The exposure of the spring treated seed to light and air, for 2 to 3 weeks before required for cutting and planting, facilities the growth of thick, stubby sprouts (11) and contributes toward increased yields. It is important to label conspicuously any stored treated-seed, on account of the poisonous nature, to prevent the tubers being used as food.

Methods of Analysis

In the following experiments, mercuric chloride was determined by the laboratory method of the authors (4). Agencies and practices, which might have prevented the successful application of the method, were excluded from the long soak disinfection process; 50 or 100 ml. aliquots of the 1 : 1000 solution, without filtering, were found suitable. For the solutions, acidulated with acetic acid, it was found necessary to carry the titration to a distinct, permanent blue end point, in contrast to the bluish tinge end point for solutions containing no acid. The acidulated 2 : 1000 solution of mercuric chloride did not require filtering and 25 or 50 ml. aliquots were found satisfactory for titrations.

The authors' laboratory and field methods (4, 5) were compared with Jamieson's volumetric (7), in determining mercuric chloride in solutions, which had been used for the long soak potato disinfection. The results, in Table 1, represent averages, from triplicate analyses. The authors' simple titration methods, with their sharp end points, are rapid, convenient and sufficiently accurate, compared to the longer method of Jamieson, which requires a long precipitation and a subsequent slow titration with chloroform.

TABLE 1.—COMPARISON OF ANALYTICAL METHODS

Mercuric chloride per litre solution			Number of lots treated by solution
Authors' laboratory	Method of analysis Authors' field	Jamieson's volumetric	
gm.	gm.	gm.	
0.851		0.849	One
.729		.723	One
.926		.940	One
.942	0.925		One
.812	.800		Two
.962	.950		Two
.808	.786		Three
.946	.900		Three
.843	.833		Four
.962	1.000		Four

STRENGTH-CONTROL FOR EFFECTIVE DISINFECTION BY THE STANDARD LONG SOAK

These experiments were undertaken to determine how many successive lots of potatoes might be treated by the repeated use of the original solution. The strength of the solution was controlled by systematic testing and adjusting (4, 5). The tubers were washed by soaking in tap water for 3 hours or more. Eight-pound successive lots of washed seed were immersed for 1½ hours in 5 litres of aqueous mercuric chloride solution, prepared with 100 ml. of 5% "stock". Following the initial testing, the strength of the solution was tested 3 times after each treatment, viz., immediately after seed disinfection, again after the addition of water to restore the volume and finally, after the addition of the 5% "stock" to adjust the strength for the next batch.

In general practice, field or laboratory, after checking the initially prepared solution for strength of mercuric chloride, 1 : 1000, only one testing and adjustment per treatment is required, or possibly only one testing and adjustment for every 3 treatments, viz., after the addition of water to restore the volume. The general procedure and the changes of mercuric chloride content may be followed in Tables 2 and 3 for nine successive lot treatments of potatoes in glass and wooden vessels.

Treatment in Glass Vessel

Small tubers, weighing 1½ to 6 ounces, were treated in a glass vessel. The mercuric chloride losses, shown in Table 2, averaged 5.8% for 9 successive lot treatments. As the glass vessel exerts no reducing effect (6), the entire loss must have been effected by the small tubers with their large surface exposure.

TABLE 2.—EFFECTIVE DISINFECTION OF WASHED POTATOES IN GLASS VESSEL

Successive lot of washed tubers	Strength at start	*Strength after 1½ hours	Reduction of $HgCl_2$	Water added to restore volume	Strength after adding water	Ml. 5% "stock" added	Strength after adjustment
			%				
1	.990	.930	6.7	480	.841	16	.942
2	.942	.869	7.7	280	.812	19	.962
3	.962	.924	4.0	500	.808	19	.946
4	.946	.895	5.4	325	.843	16	.962
5	.962	.911	5.3	500	.815	19	1.005
6	1.005	.950	5.5	150	.923	11.5	1.018
7	1.018	.985	3.2	250	.930	7	1.081
8	1.081	.962	11.0	200	.923†		
9	1.009	.974	3.5				
Average			5.8				

* Strength denotes gram mercuric chloride per litre.

† After this stage, the solution stood for 8 days and required 175 ml. water and 10.5 ml. "stock" to adjust the strength for the 9th lot treatment.

Treatment in Wooden Vessel

Large tubers, weighing 8 to 12 ounces, were treated in a wooden pail, previously scrubbed, rinsed thoroughly and water-soaked for 24 hours. The loss of mercuric chloride averaged 5.7%, for the nine treatments, Table 3, part of this loss being effected by the wooden vessel (6), which

would average around 0.5 to 1%. Accordingly, the actual mercuric chloride loss, effected by the large tubers, themselves in wooden treating vessel, would average possibly around 4.5 to 5%.

TABLE 3.—EFFECTIVE DISINFECTION OF WASHED POTATOES IN WOODEN VESSEL

Successive lot of washed tubers	Strength* at start	Strength after 1½ hours	Reduction of $HgCl_2$	Water added to restore volume	Strength after adding water	Ml. 5% "stock" added	Strength after adjustment
			%				
0	.955	.919	3.8	150	.885	11.5	.978
1	.978	.898	8.2	215	.865	15.5	1.000
2	1.000	.935	6.5	525[1]	.712	29.0	.925
3	.925	.875	5.4	150	.848	15.6	.994
4	.994	.966	2.9	350[2]	.785	22.8	.994
5	.994	.922	7.2	225	.879	12.0	.994
6	.994	.946	4.8	200	.910	11.3	1.002
7	1.002	.966	3.6	225	.931	7.4	.986
8	.998[3]	.926	7.1	700[4]	.798	21.4	.994
9	.994	.974	2.0				
Average			5.7				

* Strength denotes gram mercuric chloride per litre.
[1] Solution had stood 18 hours before the addition of water.
[2] Solution had stood 16 hours before the addition of water.
[3] Before making 8th treatment, the solution had stood for 7 days and required 550 ml. water and 60.4 ml. of 5% "stock" for adjustment.
[4] Solution had been withdrawn for sampling purposes.

Although the comparatively large additions of water, to restore the volume, shown in data of Tables 2 and 3, caused greater reductions in strength than the individual treating processes on the 5 litre solution basis, this effect would be negligible on the 25 or 50 gallon-field-basis.

THE ACIDULATED CORROSIVE SUBLIMATE TREATMENT IN WOODEN VESSEL

As a preliminary experiment, 2½ litres of solution, containing 40 ml. of 5% "stock" mercuric chloride solution and 16.7 ml. of glacial acetic acid (99.5%) per litre, in a wooden pail, were stirred occasionally to ascertain the changes in acid and salt contents that occur. The effect of the wooden treating vessel on the mercuric chloride and acetic acid contents of the treating solution is shown in Table 4.

TABLE 4.—THE EFFECT OF WOODEN VESSEL ON THE MERCURIC CHLORIDE AND ACETIC ACID CONTENTS OF THE TREATING SOLUTION

Time in hours	Mercuric chloride			Acetic acid		
	Per 1000 ml. solution	Loss	Rate loss per 10′	Per 1000 ml. solution	Loss	Rate loss per 10′
	gm.	%	%	gm.	%	%
0	2.016			16.663		
½	1.968	2.33	.78	16.663		
17	1.680	16.7	.16	15.677	5.93	.06
21	1.624	19.4	.16	15.283	8.28	.07
22	1.600	20.6	.16	15.431	7.34	.06
39	1.488	26.2	.11	15.530	6.80	.03

The loss of mercuric chloride caused by the wooden vessel per 10-minute-treatment was less than 1% for the first few treatments, but for subsequent treatments, the loss rate diminished: after 17 hours the total percentage loss was considerable, being 16.7%, but the corresponding percentage rate loss per 10 minutes of 0.16% was quite small. Unfortunately, analyses were not made for the 5- and 10-hour periods. The loss of acetic acid was small and proportionately less than that of mercuric chloride.

The Effect of Successive Treatments of Unwashed Potatoes on the Acidulated Solution

A bag of Green Mountain potatoes was supplied by the Field Husbandry Division to study the losses of mercuric chloride that occur from successive lot treatments. Each lot of unwashed potatoes, 4 lb. per lot, was soaked for 10 minutes in 5 litres solution-mixture of acetic acid and mercuric chloride, contained in a wooden pail. The concentrations of the reagents used to prepare the treating solution and the results of the experiment are given in Table 5. The ultimate purpose of the experiment was to decide, from the losses of mercuric chloride and acetic acid that occur, how many successive lots of seed might be treated by repeated use of the original solution without the need of strength adjustment.

Twenty successive lots of seed were treated by hand, for 10 minutes each, in less than 5 hours; less than 10% mercuric chloride and 5% acetic acid losses were found in the final solution, Table 5; Plummer and Bonde, treating in a porcelain vessel for 5-minute periods, found a total loss of less than 8% mercuric chloride and 2% acetic acid, from 25 successive lots of potatoes and that 89% effective disinfection for rhizoctonia resulted as shown by examination of stem lesions. In the present experiment, with the doubled time of treatment, 10 minutes instead of 5, it is reasonable to say that the disinfection would be more than 90% effective and that considerably more than 20 successive lots of unwashed potatoes might be treated in wooden vessels.

It is significant that: acidulation (Table 5) prevented the rapid loss of mercuric chloride experienced in the non-acidulated solutions (Tables 2 and 3); the losses, according to Table 5, averaged less than 0.5% per treatment compared to about 6% in Tables 2 and 3; the mercuric chloride was depleted faster than the acetic acid in the acidulated solution.

The volume of the solution was measured at the end of the experiment to determine the amount removed by the treated tubers; less than 2% of the volume of solution was lost in removal by the tubers. On a 25- or 50-gallon solution-basis, the loss would be negligible, if neither sacks nor crates were used to immerse the tubers.

DISCUSSION

For the long soak process, Tables 2 and 3, the solution was used 9 times to treat successive lots of washed tubers by means of testing and adjusting for volume and strength before each subsequent treatment. Under such a procedure, the solution might be used indefinitely. It is

TABLE 5.—REDUCTION IN STRENGTH OF MERCURIC CHLORIDE AND ACETIC ACID EFFECTED BY SUCCESSIVE TEN MINUTE TREATMENTS OF 4 LB. LOTS OF UNWASHED POTATOES IN 5 LITRES OF ACIDULATED MERCURIC CHLORIDE SOLUTIONS

Successive lot treated	Mercuric chloride		Acetic acid	
	Gm. per 1000 ml. solution	Percentage lost	Gm. per 1000 ml. solution*	Percentage lost
0	2.032†		17.107‡	
1	2.008	1.13	17.206	
2	1.992	1.97	17.009	0.57
3	1.968	3.15	16.911	1.72
4	1.976	2.76	16.762	2.02
5	1.960	3.54	16.762	2.02
6	1 936	4 72	16 960	.86
7	1.920	5.51	16.960	.86
8	1.920	5.51	16.960	.86
9	1.896	6.69	16.566	3.16
10	1.904	6.30	16.862	1.43
11	1.888	7.09	16.762	2.02
12	1.872	7.87	16.911	1.15
13	1.880	7.48	16.762	2.02
14	1.880	7 48	16.664	2.59
15	1.872	7.87	16.615	2.88
16	1.864	8.27	16.566	3.16
17	1.872	7.87	16.664	2.59
18	1.856	8 66	16.762	2.02
19	1.856	8.66	16.469	3.73
20	1.832	9 84	16.368	4.32
Average per treatment		.492		.216

* Obtained by titrating 5 ml. of solution with 0.1 N sodium hydroxide and phenolphthalein indicator.

† Equal to 40 ml. of 5% "stock" per litre or 1 imperial gallon of 5% "stock", viz., 8 ounces mercuric chloride per 25 imperial gallons of treating solution.

‡ Equal to 16.7 ml. or 3¼ imperial pints of glacial acetic acid (99.5%) per litre or 25 imperial gallons of treating solution, respectively.

possible that testing and adjusting of the solution, after every 3rd successive lot, instead of after each treatment, may be sufficient, if tubers be washed previously, because the strength of mercuric chloride would not be reduced more than 20%, viz., 5.7% average per treatment (Table 3) in wooden vessels. Plummer and Bonde (9) obtained 97% rhizoctonia control by the long soak process in .78/1000 mercuric chloride solution.

The acidulated treatment may be used to advantage, if the standard long soak be considered too long, troublesome and expensive. In a wooden treatment vessel, 20 successive lots of unwashed tubers were treated without the need of testing and adjusting the mercuric chloride solution for volume and strength; the strength of mercuric chloride was depleted less than 10% and that of acetic acid only about 4% (Table 5). It is reasonable to believe that the solution might be used effectively for many more times until about 20% of the mercuric chloride is lost. At any rate, the partially exhausted acidulated solution need not be discarded; it can easily be restored to the original strength (4, 5), and used to treat further successive lots of seed. If the tubers were washed before treating, it is estimated that as many as 40 to 50 successive lots of seed potatoes might possibly

be disinfected by the 10-minute soak in acidulated solutions without the need of adjustment. This assumption is made on the fact that Plummer and Bonde (9) obtained 89% rhizoctonia control of unwashed tubers treated 5 minutes in acidulated solutions of mercuric chloride reduced to about 1.85 : 1000. Accordingly, the maximum number of successive lot disinfections, of washed and unwashed seed tubers by the 10-minute soak in acidulated solutions, is a problem which requires investigation by the plant pathologists.

It should be borne in mind that sacks, crates and soil are the chief offenders in reducing mercuric chloride of seed potato disinfection solutions (6). Accordingly, the practice of using sacks and crates in the process should be discontinued; as much soil and refuse as possible should be kept out of the solution, whether acidified or not; sacks, containing seed to be treated, should not be emptied directly into the disinfection solution on account of the soil and refuse content.

The treating of seed in the fall or winter, or 30 days before planting, appears to offer the best insurance for increased yields in dry seasons. Tuber injury may be prevented by thoroughly drying the seed before storing in containers. No tuber injury resulted from any of the treatments of these experiments.

SUMMARY

For the control of tuber-borne diseases, by treating washed potatoes for 90 minutes in 1 : 1000 mercuric chloride solution, it was possible to control the strength of mercuric chloride in successive lot treatments by the authors' simple method of testing and adjusting; 9 successive lots of tubers were treated by the repeated use of the original solution; the loss of mercuric chloride averaged less than 6% per treatment.

For those who consider the standard treatment too long and expensive and the matter of strength-control too troublesome, the alternative acidulated treatment offers advantages which should meet the popular demand. The presence of acetic acid prevented the rapid depletion of mercuric chloride, which occurred in non-acidulated solutions. Twenty successive lots of unwashed potatoes were treated in a wooden vessel, containing 2 grams mercuric chloride and 16.7 ml. glacial acetic acid per litre, without need of adjustment of any kind. At the end of the experiment, a total of less than 10% mercuric chloride and 5% acetic acid was lost.

Some advantages of the acidulated treatment, compared to the "non-acidulated long-soak", are as follows: 20 or more successive treatments can be made in suitable wooden vessels without adjustment of solution; only 10 minutes are required instead of 90; the tubers need not be washed; acidulation with acetic acid is not injurious to tubers, human skin or clothing; and a considerable saving in labour and material costs is possible.

It should be remembered, for effective control of tuber-borne diseases, that sacks, crates or hampers and as much soil and refuse as possible, should be kept out of the corrosive sublimate solution, whether acidified or not.

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PRESERVATIVES FOR FARM FENCE POSTS

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[Received for publication January 27, 1944]

The maintenance of serviceable fences on farm and ranch lands in the Prairie Provinces of Canada is one of the unavoidable expenses of operators of such lands. Durable woods for this purpose such as round and split cedar and tamarack have become extremely scarce, and are now practically unobtainable. This situation has compelled the general use of less durable posts of native and introduced species of trees.

On the plains it is becoming more difficult every year to obtain post material of any description. A generally drier soil and less precipitation than elsewhere, however, tends to retard the process of post decay, so that untreated fence posts have a service life somewhat longer than under conditions more favourable for the development of decay-producing fungi.

At the Dominion Forest Nursery Station, Indian Head, Saskatchewan, widely known as the source of trees for shelter-belt and woodlot planting, studies in testing materials for preserving home grown fence posts have been carried on for many years. Methods of treatment are of practical application on any farm.

The more commonly known wood preservatives creosote, zinc chloride and copper sulphate (bluestone) have been used in these tests. Over 800 treated and untreated posts of different tree species locally grown have been under test to observe their durability. An attempt was made to ascertain the amount of preservative and time of treatment necessary for maximum post durability. As would be expected these vary with the different species, and are also influenced by the conditions where the posts are permanently set out.

It has been established that superficial treatment of posts such as dipping for a few minutes or applying the preservative with a brush is not effective in preventing decay. Posts treated by these methods do not last appreciably longer than untreated posts. They are therefore not considered useful.

UNTREATED POSTS

The durability of untreated posts is governed by the period of seasoning before being set out. Slow seasoning is very important and desirable. The time of cutting the posts also affects future durability. Winter is the best time to cut posts as the seasoning process is then well advanced before decay-producing fungi become active in summer.

Untreated posts if thoroughly seasoned before being placed in the ground will last years longer than posts of partly seasoned or green cut wood. The recent drought decade also prolonged the service life of prairie

[1] Forest Engineer and Superintendent, respectively.

farm fence posts, which under normal weather conditions, would have required replacing in that period. With a return of normal moisture conditions a very heavy demand for new fence posts may be expected.

TABLE 1.—DURABILITY OF UNTREATED POSTS IN WELL-DRAINED, UPLAND CLAY LOAM*

Species	Range of durability	Average durability
	years	years
Russian poplar	12 to 18	15.5
Aspen poplar	11 to 16	14.0
Willow (acute leaf)	8 to 17	13.5
Maple (box elder)	9 to 16	11.5
White birch	7 to 13	9.5
Cottonwood	7 to 9	8.0
Siberian larch	7 to 18	14.5
Tamarack	9 to 17	14.0
European larch	8 to 12	10.5
Scots pine	8 to 12	10.0

* Records summarized after 18 years—1943.

From figures presented in Table 1 it will be seen that the average durability of Russian poplar, aspen poplar and acute willow is equal to that of Siberian larch, tamarack, and slightly longer than that of European larch and Scots pine.

The record of untreated Russian poplar posts is of particular interest. Being a fast-growing variety under prairie conditions post size wood can be grown in from 7 to 10 years. It responds readily to preservative treatment as will be seen in Table 2. Treatment with a satisfactory preservative may be expected at least to double the service life of Russian poplar posts.

TREATED POSTS

Materials used as preservatives of fence posts in tests begun at Indian Head in 1926 were, creosote, zinc chloride, creozol, and copper sulphate (bluestone). For all treatments except bluestone posts were peeled and seasoned prior to treatment. Posts used were an average length of 7 feet and varied in diameter from 3 to $5\frac{1}{2}$ inches. The butts were treated to a height of 30 inches.

Creosote

Various methods of treating posts with creosote were outlined, namely:

Treatment A. Posts set upright in an open iron tank of creosote maintained at a temperature of 200° to 230° F. for 20 minutes.

Treatment B. Posts dipped in hot creosote for 2 or 3 minutes.

Treatment C. Posts kept in a tank of creosote maintained at a temperature of 200° to 230° F. for 1 hour, then left to cool in the creosote for 10 hours.

Treatment D. Check, posts untreated.

TABLE 2—DURABILITY OF CREOSOTE-TREATED POSTS IN WELL-DRAINED, UPLAND CLAY LOAM*

Species	Treatments							
	A (96 posts)		B (96 posts)		C (48 posts)		D (48 posts)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Russian poplar	62.5	37.5	37.5	62.5	100	—	25	75
Aspen poplar	62.5	37.5	37.5	62.5	100	—	—	100
Willow	87.5	12.5	37.5	62.5	100	—	25	75
Maple	62.5	37.5	50.0	50.0	100	—	—	100
White birch	25.0	75.0	12.5	87.5	100	—	—	100
Cottonwood	75.0	25.0	12.5	87.5	100	—	—	100
Siberian larch (3)	50.0	50.0	75.0	25.0	50	50	50	50
Tamarack	75.0	25.0	50.0	50.0	100	—	—	100
European larch	50.0	50.0	50.0	50.0	100	—	—	100
Scots pine	25.0	75.0	12.5	87.5	100	—	—	100
Average	57.5	42.5	37.5	62.5	95	5	10	90

* Records in per cent summarized after 18 years—1943.
† (1) Posts still sound (2) posts decayed (3) no absorption of creosote.

The most significant observation which may be made from the data presented in Table 2 concerns the effectiveness of creosote treatment when time is allowed to permit the oil to penetrate the wood tissue (treatment C). With the exception of Siberian larch by which there was apparently no absorption of preservative, no losses of posts have occurred in any of the species tested, when given treatment C.

"Check" posts (treatment D) show a directly opposite result. Treatment A on the average, was about 60% as effective as treatment C in prolonging the service life of fence posts, while treatment B was about 38% as effective as treatment C.

Zinc Chloride

Zinc chloride, like copper sulphate (bluestone), is a water-soluble salt, but the strength of the solution must be carefully regulated. A solution of greater concentration than 5% (20 lb. in 40 gallons of water) is likely to weaken the strength of the wood.

For this treatment the solution was maintained at a temperature of 190° to 200° F. for one-half to one hour. Besides being left in the solution while it was heated the posts were left to cool in it for 36 hours. Sixty-seven aspen poplar posts were used for the zinc chloride treatment. The average diameter of these posts at ground line was $4\frac{1}{2}$ inches.

"Survival" of posts in 17 years from this treatment was 88%. Comparable untreated posts had all decayed in 10 years. Painting *zinc* chloride on the butts of aspen posts was not effective in lengthening their durability.

Creozol

The formula for this preservative is not known. It is a preparation known as Coderre's Special, having been developed by Mr. Coderre, formerly in charge of wood preservation, Dominion Forest Products Laboratory, Montreal, Canada.

Treatment consisted of setting the aspen poplar posts in the cold liquid in an open tank to a depth of 30 inches for 12 hours.

In this treatment 29 of a total of 82 posts treated showed no absorption of preservative; they weighed exactly the same after treatment as before. This also occurs with "close" grained woods with other treatments.

The remainder of the posts used in this treatment showed good absorption of preservative liquid. Strangely enough those which absorbed the greatest amount of preservative lasted only from 7 to 11 years, while a number of posts which absorbed the least amount of preservative were still sound after 16 years.

One explanation of this result is that the higher concentration of Coderre's Special weakened the strength of the wood.

From this treatment the average durability of posts was 11 years. "Survival" of posts treated with Coderre's Special (Creozol) in 16 years was 13.4%. Half of the posts which were sound after 16 years absorbed practically no preservative.

Copper Sulphate (Bluestone)

Bluestone treated posts have not been tested for more than 7 or 8 years. Posts treated with this preservative are still sound.

Tests of bluestone as a post preservative have been conducted at other points in the Prairie Provinces. From these tests it is safe to say that the effectiveness of bluestone in prolonging the life of fence posts has been adequately proven.

In a circular *The Bluestone Treatment for Poplar Posts*, published by the Dominion Range Experimental Station, Manyberries, Alta., the following statements are made:

> "Bluestoned poplar on this Station after being in the ground 10 to 12 years, are just as sound as the day they were put in. Untreated poplars have rotted off in from 2 to 4 years. Cases are known in this locality of ranch fences built with bluestoned poplars in 1903 having over 70% of the original posts still in service in 1938."

Tests of bluestone as a post preservative are also being made at the Dominion Experimental Station, Scott, Sask.

Posts can be treated quickly and economically with bluestone. A saturated solution containing from 2½ to 3 pounds of bluestone per gallon of cold water, is recommended. Because this solution corrodes metal it must be prepared in a wooden container.

Only green or unseasoned posts respond readily to bluestone treatment. The treatment consists of placing the bottom ends of posts in the solution to a depth of 18 to 36 inches. Due to loss of moisture at the top by transpiration the solution quickly permeates the cells throughout the length of the posts. As moisture is given off bluestone solution is taken up to replace it.

Before the posts are placed in the solution the portion which will be in the ground is peeled completely. So that the upward movement of the bluestone solution may be watched it is wise to peel a strip a few inches

wide along one side of each post. When the solution is seen to have reached the top the treatment may be considered completed.

In warm spring weather, treatment outdoors may be completed in 12 hours. Where a number of posts are to be treated water and bluestone must be added as required. At the Dominion Experimental Station, Scott, Sask., posts of an average top diameter of $5\frac{1}{2}$ inches absorbed on the average 20 ounces of bluestone solution.

When treated posts are piled to season some are likely to split. This does not seem to decrease greatly the strength of the posts provided the solution penetrated beyond the sap wood to the pith or heartwood. This is especially necessary for the end of the post which goes into the ground.

Tamarack—Untreated

Tamarack posts in this test were distinct from those included in Table 1. The former were part of a specific test planting while those referred to here form part of the supports for the overhead irrigation line. Tamarack ranks among the strongest of soft wood species, being close grained, hard and durable. Like many woods of a hard nature tamarack does not readily absorb preservatives in the open tank method of treatment even when given a prolonged treatment.

As is true of cedar, tamarack is very scarce, and available supplies for posts fall far short of the demand. Untreated tamarack posts, when properly seasoned, almost equal cedar in durability.

Ninety-one untreated tamarack posts produced at Indian Head Forest Nursery Station have been under test for 16 years. The average diameter of the posts was $3\frac{1}{2}$ to 4 inches.

After 16 years, 75% of them are perfectly sound. Between the ninth and sixteenth years 25% became unserviceable. The probable average *minimum* durability of untreated tamarack posts of this size would therefore be about 11 years.

Cedar

Untreated cedar has a high durability rating among woods used for fence posts; 114 round untreated cedar posts of an average top diameter of 4 inches have been tested at Indian Head Forest Nursery Station (supports for overhead irrigation system).

After 16 years, 89% of these posts are still sound without evidence of decay. The 11% which have become unserviceable at the ground line still possess good heart wood which would keep the posts in service several years longer if the pull and strain on them was not too great. Posts considered unserviceable were eliminated from the test between the ninth and sixteenth years.

Untreated cedar posts of the size used in this experiment are therefore considered to have an average *minimum* durability of 12 years.

SUMMARY

The average durability of untreated fence posts of various tree species has been determined (Table 1). Untreated posts that have been well seasoned before being placed in the ground are believed to have greater durability than posts cut green and placed in the ground without seasoning.

Various treatments in the use of creosote as a preservative were tested. Greatest durability resulted from setting posts to a depth of 30 inches in creosote heated to a temperature of 200° to 230° F. for 1 hour and allowing them to cool off in the creosote for 10 hours (Treatment C, Table 2).

The "survival" of posts treated in a 5% solution of zinc chloride heated to 190° to 200° F. for one-half to one hour, and allowed to cool in the solution for 36 hours was slightly less than the "survival" from the best creosote treatment (treatment C).

FIGURE 1. Posts of different tree species cut, peeled, and piled for seasoning before Creosote preservative treatment. F.N.S. Indian Head, Sask.

Creozol proved to have much less value than creosote as a post preservative.

Bluestone, when used as a saturated solution on green cut poplar posts would seem to increase greatly their durability. This treatment is simple and economical.

The average durability of untreated tamarack and cedar posts is slightly less than that of posts of different species subjected to the most effective chemical treatments.

Tests reported on in this paper are continuing. The object is to ascertain for the benefit of shelterbelt and woodlot planters in the Prairie Provinces the probable durability of home-grown fencing material.

An attempt has been made to indicate the likely difference in the service life of treated and untreated posts of various tree species.

AGRICULTURAL EXPERIMENT STATION

Farmers, with established shelterbelts on farms throughout the Prairie Provinces have access to a great deal of fence post material. A gradual thinning of these shelterbelts should solve in large measure the problem of new and replacement fence posts.

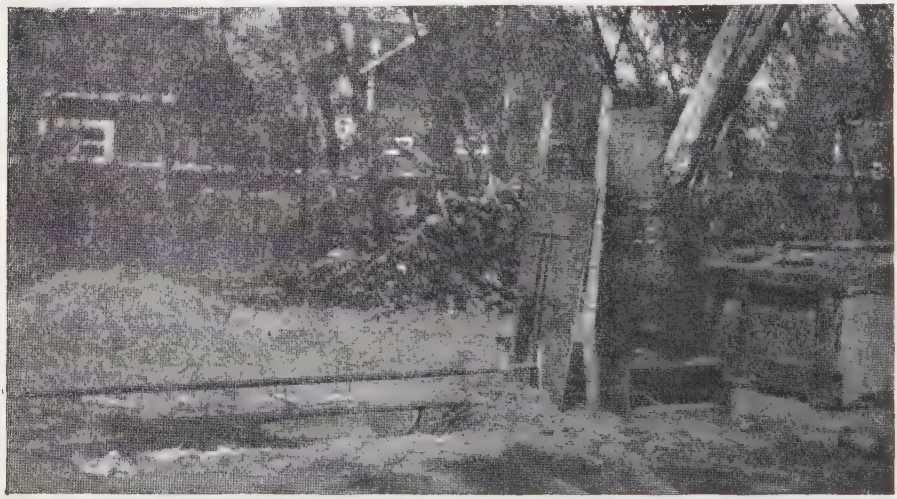

FIGURE 2. Oil circulation pipes over fire pit and connected with Creosote container. F.N.S. Indian Head, Sask.

FIGURE 3. View of testing ground in 1943 after 18 years; 50% of posts still sound. F.N.S. Indian Head, Sask.

MICROBIOLOGICAL ASPECTS OF EGG POWDER[1]

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[Received for publication February 19, 1944]

Although small quantities of spray-dried egg powder had previously been produced in Canada, the decision of the British Ministry of Food early in 1942 that all eggs should subsequently go forward in powder form created tremendous problems overnight. The production of millions of pounds of egg powder of a quality high enough to make an acceptable dish of scrambled eggs for the British consumer some months later meant that a great deal had to be learned regarding the entire process. That remarkable progress has been made in quality improvement is evident from the very high reputation enjoyed by Canadian egg powder in Britain; much of this can be attributed to the excellent co-operation between the Special Products Board and its technical advisers on the one hand, and the drying plant operators on the other.

Anyone who has smelt a rotten or musty egg should appreciate what bacterial growth can do to egg quality. However, eggs used for drying are first candled and graded; then when broken out they are again carefully inspected for abnormal appearance, and smelt to detect any off-odour. With the high quality of eggs being broken for drying in Canada (84% Grade A, 16% Grade B in 1943) the initial product contains very few bacteria (6, 7, 11, 12, 15), but in a small proportion, mostly soiled eggs, bacteria have penetrated the shell. Given favourable temperature conditions these organisms will grow rapidly and cause spoilage, hence the need for temperatures near their freezing point if eggs ear to be held for any extended period. The broken-out eggs, commonly referred to as melange, generally contain relatively few bacteria (8); if the melange is handled in properly sanitized equipment and kept sufficiently cold before drying, the resultant powder should show a very low count. (The drying process itself may destroy as high as 99.5% of the organisms in the melange (8), although the average reduction is much less than this (2, 4).) Unfortunately, plant sanitation and practices are not always what they should be; when conditions are not right, higher counts on the powder may be anticipated. Consequently, as a means of checking on plant practices, limits for total viable count and for *E. coli* were incorporated in the specifications for the 1943 contract.

OFFICIAL BACTERIOLOGICAL CONTROL OF CANADIAN EGG POWDER

Standards

Since little was known regarding the proper limits for bacterial content in egg powder, the standards finally agreed upon were a compromise between the views of the British Ministry of Food, the Special Products Board and its technical advisers, and the driers. They were as follows:

[1] Contribution No. 182 (Journal Series) from the Division of Bacteriology and Dairy Research, Science Service, Department of Agriculture, Ottawa, Canada.

[2] Associate Bacteriologist.

Grade A Powder (prime powder for use in fresh egg dishes); total viable count after 48 hours incubation at 37° C. shall not exceed 500,000 per gram, with *E. coli* absent from 1/100 gram.

Grade B Powder (residual fractions, for baking purposes only); no limit for viable count, but *E. coli* absent from 1/1000 gram.

A tolerance of one car in four exceeding either the viable count or *E. coli* limits without the penalty of degrading[3] was agreed upon for Grade A powder, provided the presence of Salmonella types (other than *S. pullorum*), hemolytic streptococci and coagulase positive staphylococci could not be demonstrated. (This proviso regarding the absence of certain pathogenic types was suggested by the British Ministry of Food, who suspected that dried eggs might have been responsible for outbreaks of Salmonella food poisoning in Britain. However, in the absence of convincing evidence that such suspicion is justified, the reference to pathogens has been dropped from the 1944 specifications.)

Methods

Simplified Technique

While certain bacteriological studies on dried eggs had been carried out by the Division of Applied Biology, National Research Council (4, 16), the official control work became the responsibility of the Division of Bacteriology and Dairy Research, Science Service, Department of Agriculture, on January 1, 1943. In addition to this routine work, investigations on various points, both in the drying plants and in the laboratory, have been carried on. Work was immediately commenced on the development of methods of analysis which would be better suited to routine control than were the research methods previously used (16). To this end, the standard agar medium employed in official milk control (1) was substituted for proteose peptone-tryptone agar, shaking of the primary dilution of powder with broken glass was substituted for the more laborious grinding with sand, while the number of tubes of Brilliant Green lactose bile broth used in the detection of *E. coli* was reduced from 20 or more to 5 per sample. In the latter connection, time was saved by the use of a single long copper cap covering the tops of all 5 tubes, in place of individual cotton stoppers. A detailed description of the official methods of analysis appears in Appendix A.

Preparation of Sample

Plating out from several replicate portions of certain samples soon revealed the need for a more adequate technique of mixing the sample. The official carlot sample, taken by the inspector at the plant, is a composite of portions taken from 80 or 90 packages. Since the bacteria count often varies greatly during a single day's drying operations (8), the composite sample may contain portions of powder of widely different bacterial content. After experimenting with a number of methods, the one finally adopted consisted in running the powder twice through a sterilized household flour sifter with a 4-armed rotating beater. Replicate portions of powder so treated showed a more satisfactory degree of uniformity in counts.

[3] Degrading of a carlot of powder from Grade A to B meant a reduction of 5c. per pound in the drying charge paid the drier—approximately $3,000 per carlot.

A Simple Test for Plant Control Work

Since the driers were to be severely penalized financially whenever a carlot of otherwise satisfactory powder failed to meet the bacteriological standards for Grade A powder, consideration was given to the possibility of developing a simple plant test whereby the drier could check his product from day to day to assure himself that his counts were not too high. To this end, the methylene blue and resazurin reduction tests (1), widely used in milk control, were adapted for use with egg powder. The powder was reconstituted by adding 2.5 gm. to 7.5 ml. of sterile physiological saline in a $\frac{5}{8}'' \times 6''$ test tube containing broken glass, stoppering and shaking for a minute or two until the powder had gone into suspension. The reconstituted powder then had approximately the same moisture content as the melange before drying. The usual dye concentrations (1 : 300,000 methylene blue or 1 : 200,000 resazurin) were employed, and tubes were incubated at 37° C.

Because of the wide differences in the intrinsic colour of reconstituted powder from one sample to another, considerable difficulty arose in determining the degree of colour change. This was particularly true with resazurin. Consequently it was decided to concentrate on methylene blue, using complete reduction as the end-point. The comparative plate counts and methylene blue reduction times for 80 samples of powder tested between November 1942 and February 1943 are shown in Figure 1. It will be observed that the average reduction time for a given plate count is considerably longer than for an equivalent bacterial content in milk. This means that incubation would have to be continued for an inconveniently long time in order to detect all samples with plate counts in excess of 500,000 per gram.

Since this work was conducted, Scott and Gillespie (14) have described the use of the resazurin test as an indicator of quality in egg pulp in Australia. The test was modified by using a stronger concentration of dye (1 : 120,000), a lower incubation temperature (30° C.) and a pink end-point. The results showed a close correlation with the plate count on beef extract agar after 3 days at 25° C. However, in dealing with the quality of melange usually encountered in Canada, the test would be of limited value because of the long incubation period required. (A plate count of 500,000 per ml. was equivalent to an average reduction time of approximately 6 hours in their studies.)

A more promising method for plant work is the Burri Slant Method (1, 7). In this method a calibrated loop is employed to pick up a very small portion of the liquid (approximately 1/2,000 gram); this is then distributed as evenly as possible over the dried surface of a tryptone glucose agar slant, and the tube incubated at a suitable temperature. This method has proven exceedingly useful in connection with plant sanitation studies, and much wider use will be made of it in 1944.

Direct Microscopic Count Method

While the plate count method has been of distinct value in directing attention to faulty conditions, it was noticed that the powder from certain plants gave much lower counts than would be expected on the basis of sanitation surveys. It is generally agreed that the plate count of dried milk solids is not a reliable indication of the quality of the raw milk used, since the process of manufacture and subsequent storage have a direct bearing upon the extent to which the bacteria survive. Information at hand suggests that the same holds true for dried whole egg (4, 8). In the dried milk field the direct microscopic method furnishes valuable information concerning the previous history of the product (10), and it seemed logical to assume that this also holds true for dried eggs. Bartram (2) has recently reported that this is the case. Consequently, starting July 28, 1943, it was decided to make direct microscopic counts concurrently with plate counts.

The results of these comparative studies, which are being reported elsewhere (9), confirm the opinion that the direct microscopic count does afford a better indication of the care given the melange prior to drying. A direct microscopic count limit of 2,000,000 per gram is therefore being incorporated in the 1944 specifications for Canadian Grade A powder.

Coliform Organisms and E. Coli

The determination of coliform organisms or of *E. coli* in egg powder has not been found particularly helpful. In drawing up the specifications it was expected that there would be a fairly close parallel between total counts and the presence of these types of bacteria, as has been reported for frozen eggs (13). The data presented in Table 1 indicate that this is frequently not the case; a high level of coliforms may accompany a low count, or a low level of coliforms a high count. Furthermore, there seemed to be little agreement between the results of coliform tests and of plant sanitation surveys in several plants. In consequence, the determination of coliform organisms and *E. coli* in Grade A powder has been dropped for 1944.

Résumé of Results of 1943 Operations

That Canadian driers, with few exceptions, have done a fairly satisfactory job from a bacteriological standpoint is indicated by the summarized distribution of plate counts in Table 2. Only 10 (4.25%) of the 235 cars of Grade A powder exceeded the limit of 500,000 per gram. Of these 10 high counts, 3 could be attributed largely to slow freezing of melange stored for subsequent drying, with consequent bacterial development in the central core of the block; 2 others were due to the growth of a heat-resistant streptococcus in a tubular pre-heater, while only 2 could definitely be attributed to faulty care of equipment. Of the 3 remaining 2 (from Plant H) appeared to result from a peculiarity in the construction of the drier.

The high counts due to the use of a pre-heater are of interest. This plant (G) had used the same tubular pre-heater since commencing operations in August 1942 with a satisfactorily low level of counts. However, during February 1943 a powder cooling system was installed, whereby the powder was cooled to 80° F. or lower as it left the drying chamber. As Gibbons and Fulton (4) have reported, prompt cooling of the powder means a significantly higher number of organisms surviving. This, together with a gradual increase in the length of the day's run as production increased, resulted in a markedly higher level of counts. Studies at the plant showed that counts near the start of the day's drying were quite low (14,000 to 41,000 per gram on 4 days) while at the end of the 19-hour run counts as high as 24,000,000 per gram were obtained. This enormous increase was found to be due to the growth of bacteria in portions of the melange adhering to the rubber gaskets and to the walls of the tubes, which latter frequently showed serious scoring; the melange came from holding vats at temperatures around 35° F. and was heated to around 80° F. in the tubular heater by water at 120° F. In at least one instance, the material remaining in the tubes at the end of the run was so acid it had coagulated. The organism responsible for the high counts was found to be a streptococcus closely resembling *S. thermophilus*. It produced pin-point colonies on tryptone glucose agar, and died off very rapidly in the powder. One sample gave an initial count of 2,700,000 per gram, yet after 12 days' storage at 40° F. the count had fallen to 710,000. Upon elimination of the pre-heater the count fell abruptly, the highest at the end of the next 3 days' runs being 7,000 per gram.

Effect of Temperatures in Transit upon Bacterial Content of Egg Powder

As was previously mentioned, the viable count of bacteria in egg powder is markedly affected by the temperature to which it is exposed after leaving the drying chamber. In order to determine what bacteriological changes might be brought about in official carlot samples en route from the plants to the laboratory in Ottawa, two series of experiments were carried out. In the first experiment, samples of powder were taken directly from the sifter at a local plant on 5 successive days; in the second, similarly taken samples were shipped by express from each of 6 other drying plants. In each case the sample, after thorough mixing, was subdivided into a number of portions, each of which was exposed to a definite temperature for a definite period. Each sub-sample was then analyzed bacteriologically and the results compared with those from the initial analysis. From the average values, shown in Table 3, it appears that at 40° F. the bacteria counts showed no appreciable change even after 5 days; at 70° a moderate decline was noted after 2 days, being much more evident in the higher count samples, while at 86° to 90° a sharp reduction was noted, this being evident even after 1 day. Coliform organisms and *E. coli* appeared to die off more rapidly than the general flora at all three temperatures, the decrease being particularly pronounced at the higher temperatures.

In order to keep such changes at a minimum, consideration was first given to the use of dry ice in the shipping container. However, this had to be dropped as dry ice was not available at several points where eggs were

being dried. Instead, it was decided to have the samples cooled as thoroughly as possible before shipment. Samples from Western Canada were to be sent by air express, those from Eastern Canada by railway express. In this way all samples should reach the laboratory within 24 hours, with little or no change in their bacterial content.

Bacterial Flora of Melange and Powder

Some studies were conducted upon the flora of melange and of powder. Approximately 100 colonies from each of a series of plates prepared from samples of powder from 7 plants, and of melange from 1 plant, were fished into litmus milk and incubated at around 86° F. (30° C.) for 5 days. Smears were made from each tube, stained according to Gram's method and examined microscopically. While the flora of the single sample of melange comprised a variety of types, Gram negative rods predominated; in the powder samples on the other hand, a streptococcus which produced slight acid but failed to coagulate litmus milk was the preponderant type, often comprising over 90% of the colonies fished.

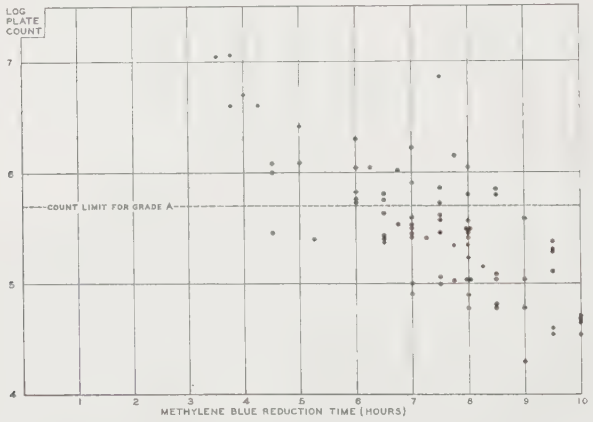

FIGURE 1. Comparative methylene blue reduction times and plate counts on 80 samples of dried egg.

SUMMARY AND CONCLUSIONS

The standards and procedure employed in the bacteriological control of Canadian dried eggs for export to Britain are described, together with some of the results for 1943. In 1943, out of a total of 235 carlots of Grade A powder, 95.75% gave plate counts of under 500,000 per gram.

As a simple plant test for bacterial content of melange, the Burri slant method has been found most useful. Dye reduction tests were not so satisfactory because of end-point difficulties and the long incubation periods required.

The direct microscopic count was found to reveal the past history of the product more satisfactorily than did the plate count, coliform or *E. coli* test.

The possible changes in bacterial content resulting from exposure of samples to various temperatures en route to the official control laboratory were investigated and arrangements made to minimize such changes.

Studies on the flora of melange and powder revealed that the Gram negative rods which predominated in the former were generally replaced by a weak acid producing streptococcus in the powder.

ACKNOWLEDGMENTS

The technical assistance of Dr. H. L. Berard in connection with much of the bacteriological analyses is gratefully acknowledged. Thanks are also due to Mr. R. E. Nicoll and other representatives of the Poultry Products Section of the Special Products Board for their ready assistance in obtaining samples of powder for investigational purposes.

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TABLE 1.—RELATION BETWEEN BACTERIA COUNTS, COLIFORM AND *E. coli* CONTENT OF CANADIAN GRADE A DRIED EGGS

Sample	Bacteria count (thousands per gram)		No. of tubes* Positive for	
	Viable	Direct microscopic	Coliform organisms	*E. coli*
A	21		3/5	3/5
B	12	220	20/20	19/20
C	41	880	15/15	11/15
D	3		12/15	10/15
E	5		11/25	8/25
F	21	880	10/20	9/20
G	55	550	15/15	10/15
H	26		2/5	2/5
I	15		5/5	2/5
J	38		8/10	7/10
K	470		0/5	
L	1,300		1/5	1/5
M	630		5/25	3/25
N	2,000		6/25	6/25
N	580		0/5	
O	1,100	12,000	0/10	
P	2,000	35,000	1/5	1/5
Q	2,000		6/25	6/25
R	1,200		2/20	2/20
S	1,100	4,100	0/5	

* Inoculated with 1/100 gm. of powder.

TABLE 2.—DISTRIBUTION OF VIABLE COUNTS ON DRIED EGGS. 1943.

Grade A		Viable counts (thousands per gram)					
Plant	No. of carlot samples	<10	10–25	26–100	101–500	501–1,000	>1,000
A	20	1	14	4	1		
B	21	1	1	9	8	0	2
C	29	2	1	10	14	1	1
D	55	19	13	21	2		
E	11		2	1	8		
F	15	1	8	5	1		
G	49	15	4	16	11	1	2
H	22				20	2	
I	13	1	1	4	6		1
Totals	235	40	44	70	71	4	6
Percentage		17.0	18.7	29.8	30.2	1.7	2.6
Grade B							
A	6		1	3	2		
B	14	1	1	5	5	1	1
C	19	0	1	9	7	0	2
D	12	4	4	3	1		
E	5			3	2		
F							
G	6		1	4			1
H	5				1	0	4
I	3	1	0	2			
Totals	70	6	8	29	18	1	8
Percentage		8.6	11.4	41.4	25.7	1.5	11.4

TABLE 3.—EFFECT OF TEMPERATURE ON BACTERIAL CONTENT OF WHOLE EGG POWDER

Series I (Averages of 5 samples)	Days held	Temperature (°F.)		
		40°	70°	86°
Plate count	0	76,400	76,400	76,400
	2	84,300	55,900	30,900
	5	79,000	50,000	7,680
Coliform organisms*	0	40.4	40.4	40.4
	2	60.2	48.8	5.2
	5	53.4	20.0	0.0
*E. coli**	0	20.6	20.6	20.6
	2	56.0	13.1	0.8
	5	18.4	1.7	0.0
Series II (Averages of 6 samples)	**Days held**	**40°**	**70°**	**90°**
Plate count	0	98,100	98,100	98,100
	1	100,000	90,900	52,600
	2	117,000	70,000	29,000
Coliform organisms*	0	8.4	8.4	8.4
	1	5.1	2.2	0.6
	2	4.2	1.3	0.3
*E. coli**	0	1.8	1.8	1.8
	1	2.9	1.8	0.3
	2	1.8	0.7	0.0

* Most probable number calculated from inoculation of 5 tubes with 0.1 gm. and 5 tubes with 0.01 gm. of powder.

APPENDIX A.

OFFICIAL METHODS FOR BACTERIOLOGICAL ANALYSIS OF CANADIAN WHOLE EGG POWDERS

(1) *Preparation of Sample*

Studies have shown that certain samples vary widely in count from portion to portion. Thorough mixing of the sample is therefore essential. Running the powder at least twice through a suitable type of flour sifter (which has previously been sterilized) has been found to give good results. Where the same sample is to be used for chemical analysis, care should be taken that it is not unduly exposed to the air because of the ease with which it picks up moisture from the atmosphere.

(2) *Reconstitution of Powder*

A 1 : 10 dilution is prepared by weighing out 11 grams of the thoroughly mixed sample into a sterile wide-mouthed jar or flask of approximately 200 ml. capacity containing a spoonful of glass beads. The contents of a dilution bottle containing 99 ml. of sterile physiological saline solution (0.85% NaCl in distilled water) are then poured into the jar or flask and the contents shaken vigorously until a uniform suspension is obtained, usually within a minute. The dilution should be allowed to stand for several minutes until the air bubbles have risen to the surface before preparing further dilutions.

If desired, the 1 : 10 dilution may be prepared by using 10 grams of powder and 90 ml. of saline.

Further dilutions are prepared by introducing 1, 10, or 11 ml. portions of the 1 : 10 dilution into dilution blanks containing appropriate amounts of sterile saline solution.

(3) *Escherichia coli Test*

From the 1 : 100 dilution five 1-ml. portions are pipetted into a similar number of fermentation tubes containing 2% Brilliant Green bile broth for the *E. coli* presumptive test. A 10-ml. or 11-ml. pipette graduated in 1 ml. is convenient for this purpose. Tubes are incubated at 37° C., and observed at intervals over 48 hours. As soon as gas formation is observed, the liquid in each of such tubes is streaked over the surface of a plate previously poured with eosin-methylene blue agar and allowed to harden. Two such streakings may be made on separate halves of the same plate. The streaked plate is incubated at 37° C. for 18 to 24 hours; the appearance of typical black metallic colonies is regarded as indicative of the presence of *E. coli.*

(4) *Total Viable Bacterial Count*

For total bacterial count, duplicate plates are prepared from both 1 : 1,000 and 1 : 10,000 dilutions. From the 1 : 100 dilution, 0.1-ml. portions may be transferred with aid of a 1.1 or 2.2-ml. pipette to the plates for the 1 : 1,000 dilution, while 1-ml. portions of the 1 : 100 dilution are transferred to a 99-ml. saline dilution bottle to give a dilution of 1 : 10,000. From the latter, 1-ml. portions are pipetted into plates for that dilution. If desired, dilutions may be prepared from the 1 : 100 dilution by introducing 11-ml. quantities into 99 ml. dilution blanks, or 10-ml. into 90 ml. blanks.

Approximately 10 ml. of medium, melted and cooled to 41–42° C., are poured into each plate and mixed with the inoculum within 20 minutes of preparing the 1 : 100 dilution. The medium employed is the standard medium for milk analysis, tryptone glucose extract agar containing 1% skim milk. If desired, the skim milk may be omitted, since it has no appreciable effect upon the count obtained with egg powders. After the medium has hardened, plates are incubated at 37° C. for 48 hours and all colonies counted with the aid of a Quebec colony counter or equivalent device. The average of duplicate plates on the dilution represents the total bacterial count.

Retest of Samples Exceeding Limits for Grade A

Should the total count exceed 500,000 per gram, or should 2 or more of the 5 fermentation tubes contain *E. coli*, a further 11 (or 10) gram sample is taken and the above analysis repeated. An additional 10 tubes containing Brilliant Green bile broth are inoculated with 1 ml. portions of a 1 : 1,000 dilution to ascertain whether the powder exceeds the limit for Grade B (not more than 4 of the 10 tubes to contain *E. coli*). The grade of the powder is then determined on the average of the results from both sets of analyses.

WHEAT STEM SAWFLY IN FLAX[1]

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[Received for publication February 28, 1944]

The wheat stem sawfly (*Cephus cinctus* Nort.) has as its primary hosts wheat and wheat-like grasses. However, in the absence of these plants, others may be selected for oviposition.

In 1942 large acreages of sawfly-infested land were seeded to flax. Many inquiries were made by farmers as to whether or not sawflies would lay their eggs in flax and, if so, would the larvae survive. That year, Mr. Horace Hockett of Shaunavon, Saskatchewan, first brought to the attention of the writer the fact that a sawdust-like deposit which resembled the condition found in sawfly-infested wheat stems could be found in some flax stems. This led to an investigation which definitely established that *C. cinctus* oviposition was quite common in flax. The study was continued throughout 1942 and 1943 to determine to what extent, if any, this insect could survive and mature in flax, and whether or not any economic loss resulted therefrom.

INVESTIGATIONS

Infestation in Relation to Date of Seeding

A general examination of some of the flax fields in southwestern Saskatchewan and southern Alberta indicated that only the early-seeded flax was infested. Dates of seeding were available in some instances and detailed examinations were made in some of these fields. Supplementary

Table 1.—Infestation and date of seeding

Date of seeding	Percentage infestation		
	Swift Current*	Lafleche	Crane Valley
	%	%	%
First week in May	67	75	80
Second week in May	30	—	25
Last week in May	0	0	0

* Replicated plots on Dominion Experimental Station, Swift Current, Saskatchewan.

examinations of early- and late-seeded flax fields scattered throughout the sawfly-infested area of Saskatchewan and Alberta further substantiated the findings given in Table 1.

Effect on the Crop

In some stems almost complete tunnelling was accomplished by the sawfly larva (Figures 1 and 2), the inside pith layer apparently being fed upon. In some instances this layer was completely removed from the underlying xylem, or wood layer.

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[2] Assistant Entomologist.

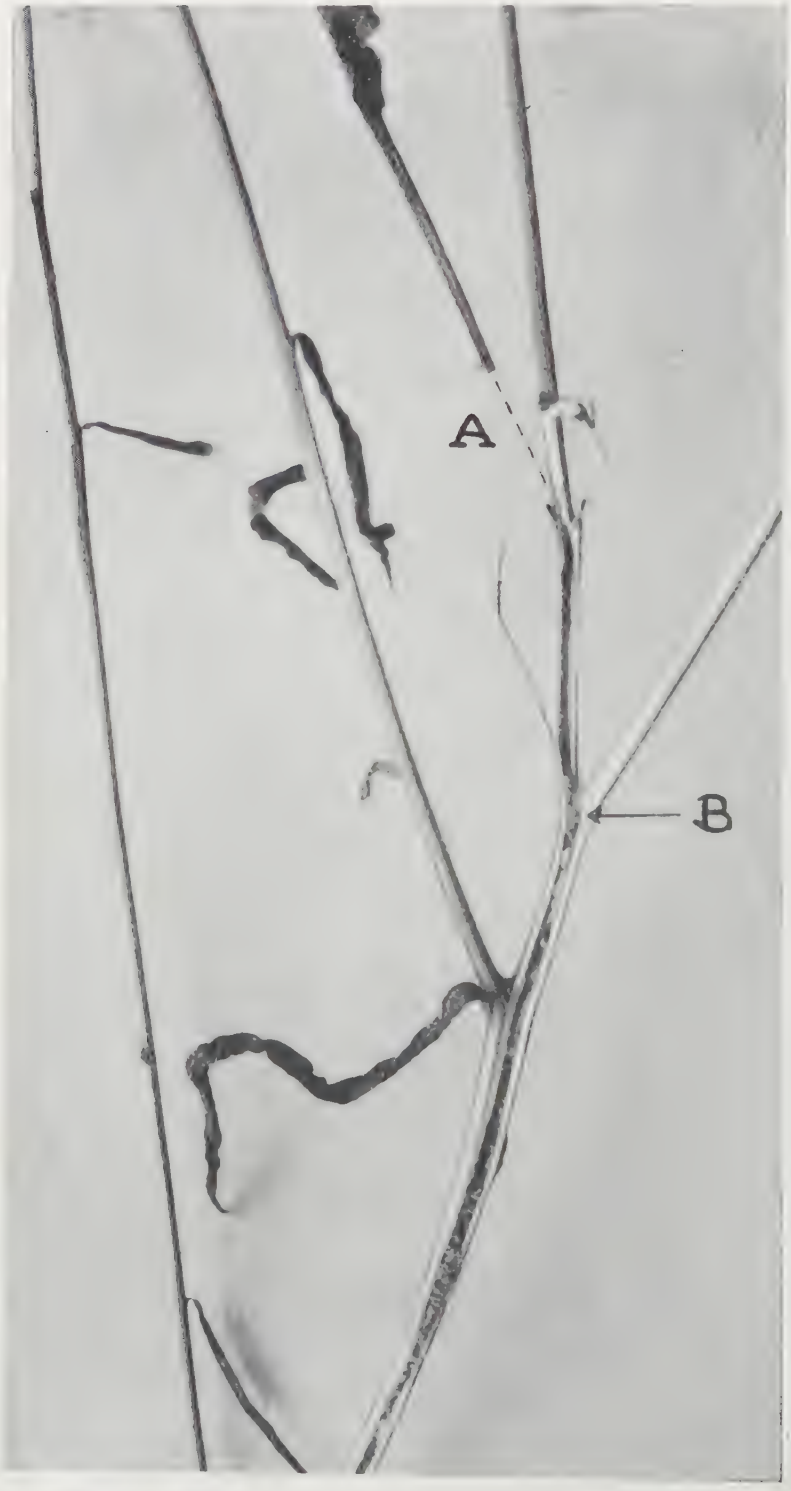

FIGURE 1. Portion of tunnelled flax plant showing severed branch (A) and position of dead larva (B). (Photograph by A. C. Budd, Experimental Station, Swift Current, Sask.)

Detailed examinations of infested stems were made to determine to what extent crop loss resulted from the feeding of the larvae. Where tunnelling of the stem was complete, well developed larvae occasionally attempted to enter small branches with the result that the branch was almost severed from the stem, remaining attached only by a few flax fibres which broke very readily as they dried out and became brittle (Figure 1).

This condition was rare and the resulting loss would be insignificant. The bolls from infested and uninfested plants were threshed by hand and

FIGURE 2. Infested flax stems. Living larvae at (A) and tunnelling in completely solid basal portion of plant (B). (Photograph by A. C. Budd, Experimental Station, Swift Current, Sask.)

examined, but there was no visible evidence of shrunken seeds or excessive sterility in the ovules which could be attributed to the damage caused by sawfly feeding.

At Assiniboia and Lafleche, Saskatchewan, in some flax fields which were severely infested, 5 to 10% of the stems on the margins showed a tendency to bend and lodge. At first this was attributed to the deep sawfly feeding pits at the point of breakage. However, closer examination

revealed that the breakage occurred only to stems which had been extensively fed upon by grasshoppers. The epidermis, cortex and the bast fibres had been stripped off, weakening the stem sufficiently to cause lodging. It was the combination of internal feeding by the sawfly larva and external feeding by the grasshoppers at the same general point on the stem, rather than either one working alone, that was responsible. Because of the branching nature of the plant it did not fall to the ground, as is the case with wheat, but was entangled with and supported by adjacent plants so that it could readily be harvested.

In some plants the woody, completely solid basal portion of the plant below the ground surface was partially tunnelled (Figure 2).

Larval Development and Growth

The rate of growth of sawfly larvae in flax is much slower than in wheat. On August 12, 1942, one hundred larvae were collected from each of two adjacent fields of flax and wheat. The stage of development of each larva was determined by measuring the width of the head capsule. Mortality counts were made at the same time. Table 2 summarizes these data.

TABLE 2.—DIFFERENTIAL GROWTH AND MORTALITY IN WHEAT AND FLAX

	Percentage of each instar				Percentage mortality
	2nd	3rd	4th	5th	
	%	%	%	%	%
Wheat	0	7	34.5	58.5	0
Flax	8	23	53.7	15.3	26

In general the larvae in flax were less active than those in wheat. As long as the flax plant remained green and succulent, a proportion of the larvae remained alive. As ripening progressed, mortality increased markedly. At Lafleche, Saskatchewan, 96% of the infested stems contained only dead larvae on September 7, 1942. In later examinations made in fields throughout Saskatchewan and Alberta, during and after harvesting, the mortality was 100%. No living larvae were found.

CONCLUSIONS

As a potential pest of flax, *Cephus cinctus* Nort. appears to be of little importance. A relatively insignificant number of branches may be severed, and in combination with grasshopper feeding some breakage may occur. The value of flax as a crop for ridding a field of its sawfly infestation probably far outweighs the small economic loss that can be directly or indirectly attributed to this insect.

RECORD OF LEPIDOPTERA CAPTURED AT A LIGHT TRAP AT NEW CARLISLE, QUEBEC, IN 1941[1]

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[Received for publication February 9, 1944]

During the course of some entomological investigations on the Gaspe Coast in 1941, a light trap was set up at New Carlisle early in July and was kept in operation until late September. The record of some of the insects taken is presented as a contribution to the knowledge of the fauna of this region.

The light trap, furnished with a bulb of 20 watts, was suspended between 10 and 15 feet above the ground. It was attached to the southern wall of a building and had a full exposure towards the southeast across open fields which had a gentle downward slope about one-quarter of a mile to the sea. The captures at the light were good during most of the summer. The most productive nights yielded from 450 to 500 specimens. As would be expected, warm, calm evenings were the most favourable for insect flight, and collections were always very large under such conditions. The largest captures were made during July, and insects came freely to the light during all of this month and during the first part of August. After that large captures were rare.

The majority of insects collected were Lepidoptera, and very few Coleoptera, Diptera or Hymenoptera were taken. Of these 157 species of Lepidoptera were identified. All identifications of the former were made by Dr. McDunnough and T. N. Freeman of the Systematic Unit of the Division of Entomology. The author is greatly indebted to these gentlemen for their assistance and co-operation. The identifications were made from selected specimens pinned and mounted in the field and brought to Ottawa at the end of the season. Although numerous specimens were taken, many species were undoubtedly overlooked. Particular attention in sorting was given to the noctuids in order to check on the species of cutworms that might be present in the region.

After the list was compiled Mr. Freeman kindly reviewed it and noted that the capture of *Sphinx canadensis* Bdv. was unusual, it being one of our rarest sphingids and occurring only sparsely throughout its range; that *Septis inordinata* Morr. was rare in collections and unusual so far north; and that *Autographa oo* Cram. represents the first Canadian record of this more southern species.

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[2] Agricultural Assistant.

The list of captures is as follows:

SPHINGIDAE

707 *Ceratomia undulosa* Wlk.
725 *Sphinx canadensis* Bvd.
727 *Sphinx kalmiae* A. & S.
739 *Smerinthus jamaicensis* form *geminatus* Say
741 *Paonias excaecata* A. & S.
798a *Celerio gallii* var. *intermedia* Kby.

AMATIDAE

884 *Ctenucha virginica* Charp.

ARCTIIDAE

980 *Halisidota maculata* Harr.
1033 *Apantesis virgo* Linn.
1065 *Diacrisia virginica* Fabr. (?)
1069 *Isia isabella* A. & S.
1070 *Estigmene acrea* Dru.
1070a *Estigmene acrea* form *dubia* Harr.

PHALAENIDAE

1130 *Panthea furcilla* var.
1141 *Raphia frater* Grt.
1148 *Acronicta americana* Harr.
1153 *Acronicta lepusculina* Gn.
1155 *Acronicta innotata* Gn.
1160 *Acronicta grisea* Wlk.
1181 *Acronicta morula* G. & R.
1185 *Acronicta fragilis* Wlk.
1195 *Acronicta retardata* Wlk.
1215 *Acronicta oblinita* A. & S.
1272 *Euxoa* sp. near *detersa* Wlk.
1292 *Euxoa perpolita* Morr.
1297 *Euxoa scandens* Riley
1378 *Euxoa ochrogaster* Gn.
1382 *Euxoa tristicula* Morr.
1382 *Euxoa tristicula* form *nesilens* Sm. (?)
1425 *Agrotis venerabilis* Wlk.
1432 *Agrotis volubilis* Harv.
1435 *Agrotis ypsilon* Rott.
1446 *Feltia herilis* Grt.
1452 *Actebia fennica* Tausch.
1472 *Spaelotis clandestina* Harr.
1475 *Eurois occulta* Linn.
1476 *Eurois astricta* Morr.
1480 *Ochropleura plecta* Linn.
1511 *Graphiphora c-nigrum* Linn.
1512 *Graphiphora smithi* Snell.
1513 *Graphiphora normaniana* Grt.
1517 *Graphiphora oblata* Morr.
1552 *Graphiphora collaris* G. & R.
1569 *Anaplectoides pressus* Grt.
1570 *Anaplectoides prasina* Schiff.
1575 *Cryptocala acadiensis* Beth.
1577 *Eueretagrotis perattenta* Grt.
1661 *Mamestra curialis* Sm.
1663 *Polia nimbosa* Gn.
1669 *Polia purpurissata* Grt.
1673 *Polia subjuncta* G. & R.
1677 *Polia atlantica* Grt.
1683 *Polia legitima* Grt.
1687 *Polia lilacina* Harv.
1687 *Polia lilacina* form *illabefacta* Morr.
1691 *Polia adjuncta* Bdv.
1693 *Polia assimilis* Morr.
1714 *Lacinipolia lustralis* Grt.
1738 *Lacinipolia renigera* Steph.
1744 *Lacinipolia lorea* Gn.
Orthodes sp.
1855 *Orthodes oviduca* Gn.
1871 *Orthodes crenulata* Butl.
1895 *Nephelodes emmedonia* Cram.
1992 *Leucania* sp. probably *insueta* Gn.
1994 *Leucania unipuncta* Haw.
1995 *Leucania* sp. probably *Luteopallens* Sm.
2038 *Cucullia intermedia* Speyer.
2042 *Cucullia postera* Gn.
2215 *Litholomia napaea* Morr.
2241 *Graptolitha tepida* Grt.
2272 *Crino* sp. probably *ducta* Grt.
2312 *Rusina bicolorago* form *ferrugineoides* Gn.
2328 *Septis verbascoides* Gn.
2335 *Septis lignicolora* Gn.
2351 *Septis arctica* Frr.
2353 *Septis alia* form *rorulenta* Sm.
2355 *Septis inordinata* Morr.
2361 *Septis commoda* Wlk.
2365 *Septis finitima* Gn.
2366 *Agroperina lateritia* Hufn.
2368 *Agroperina dubitans* Wlk.
2368a *Agroperina dubitans* form *cogitata* Sm.
2375 *Crymodes devastator* Brace
2423 *Oligia illocata* Wlk.
2424 *Oligia mactata* Gn.
2458 *Apamea velata* Wlk.
2459 *Apamea americana* Speyer.
2474 *Hydroecia micacea* Esp.

PHALAENIDAE—*Concluded*

2479 *Papaipema appassionata* Harv.
2521 *Papaipema frigida* form *thalictri* Lyman.
2533 *Euplexia benesimilis* McD.
2535 *Phlogophora iris* Gn.
2540 *Euherrichia monetifera* Gn.
2576 *Leuconycta diphteroides* form *obliterata* Grt.
2577 *Leuconycta lepidula* Grt.
2585 *Amphipyra tragopoginis* Linn.
2586 *Amphipyra glabella* Morr.
2607 *Hyppa xylinoides* Gn.
2647 *Elaphria festivoides* Gn.
2655 *Platyperigea multifera* Wlk.
2662 *Proxenus miranda* Grt.
2682 *Laphygma frugiperda* A. & S.
2715a *Pyrrhia umbra exprimens* Wlk.
2941 *Rhodophora florida* Gn.

3122 *Erastria concinnimacula* Gn.
3252 *Autographa falcifera* Kby.
3254 *Autographa rectangula* Kby.
3260 *Autographa octoscripta* Grt.
3265 *Autographa ampla* Wlk.
3266 *Autographa selecta* Wlk.
3269 *Autographa brassicae* Riley.
3273 *Autographa putnami* Grt.
3281 *Autographa precationis* Gn.
3285 *Autographa bimaculata* Steph.
3286 *Autographa mappa* G. & R.
3287 *Autographa pseudogamma* Grt.
3289 *Autographa oo* Cram.
3295 *Plusia aereoides* Grt.
3297 *Plusia balluca* Geyer
3304 *Palaeoplusia venusta* Wlk.
3344 *Catocala relicta* Wlk.
3616 *Alabama argillacea* Hbn.
3734 *Epizeuxis americalis* Gn.

3770 *Philometra* sp. probably *metonalis* Wlk.

NOTODONTIDAE

3822 *Ichthyura apicalis* Wlk.
3829 *Datana ministra* Dru.
3849 *Notodonta basitriens* Wlk.
3851 *Pheosia rimosa* Pack.
3853 *Lophodonta ferruginea* Pack.
3857 *Nadata gibbosa* A. & S.
3906 *Heterocampa biundata* Wlk.
3907 *Heterocampa guttivitta* Wlk.
3912 *Dicentria lignicolor* Wlk.
3920 *Schizura ipomoeae* form *cinereofrons* Pack.
3920 *Schizura ipomoeae* Dbldy.
3921 *Schizura concinna* A. & S.
3924 *Schizura unicornis* A. & S.
3939 *Gluphisia septentrionalis* Wlk.

THYATIRIDAE

4004 *Habrosyne scripta* Gosse

DREPANIDAE

4020 *Drepana arcuata* Wlk.

GEOMETRIDAE

4244a *Triphosa haesitata* var. *affirmaria* Wlk. (?)
Eupithecia sp.
4416 *Dysstroma* sp. probably forms *citrata* Linn.
4558 *Euphyia unangulata* var. *intermediata* Gn.
4573 *Eulype* sp., *hastata* group
4612 *Deilinea variolaria* Gn.
4614 *Deilinea erythemaria* Gn.
4664 *Philobia ulsterata* Pears.
4725 *Semiothisa neptaria* var. *trifasciata* Pack.
4908 *Anavitrinella pampinaria* Gn. (?)
4968 *Amphidasis cognataria* Gn.
5007 *Xanthotype sospeta* Dru.
5043 *Hyperetis amicaria* H.-S.
5054 *Metanema inatomaria* Gn.
5055 *Metanema determinata* Wlk.
5080 *Pero morrisonarius* Hy. Edw.
5125 *Caripeta divisata* Wlk.
5144 *Ellopia* sp., *endropiaria* group
5152a *Cingilia catenaria* var. *rubiferaria* Swett.

PYRALIDAE

5446 *Evergestis straminalis* Hbn.
5455 *Nomophila noctuella* D. & S.
5462 *Loxostege chortalis* Grt.
5561 *Phlyctaenia terrealis* Tr.
5564 *Phlyctaenia tertialis* Gn.
5724 *Eurrhypara urticata* Linn.
5725 *Scoparia centuriella* D. & S.

TORTRICIDAE

7317 *Sparganothis pettitana* Fern.

BOOK REVIEWS.

PLANT VIRUSES AND VIRUS DISEASES. F. C. Bawden. Second edition, 294 pages, 47 figs. Price $4.75. The Chronica Botanica Co.: Waltham, Mass. Wm. Dawson Subscription Service Ltd., Toronto.

This publication, prepared by one of the leading plant virus investigators, deals primarily with the nature of viruses, rather than the diseases they cause, and in this respect differs from other text books on virus diseases of plants. This second edition is larger, more up-to-date and has included certain omissions that occurred in the first edition. It gives a well rounded conception of the status of our present knowledge about viruses. It is too much to expect that there will be universal agreement with some of the conclusions contained therein, but these conclusions in turn present a challenge to other investigators.

Chapter I is "an introductory survey" and a good one at that. As in the first volume a virus is defined "as an obligatory parasitic pathogen with at least one dimension of less than 200 m.", though the author admits that this definition will most likely be modified by future work. A short history, views on the nature of viruses, and a review of the situation on nomenclature complete the Chapter. Chapters II and III relate to symptoms, Chapter II being confined to external symptoms and the effects of temperature and environment on their expression and the use of local lesions in quantitative work. In this connection the author rightly points out that this method measures the relative infectivities rather than virus content. In Chapter III the internal symptoms are discussed such as X-bodies, intracellular inclusions and other internal changes. Chapter IV gives a concise and clear interpretation on transmission under grafting, mechanical methods, insects and seed. The conclusion that, in the field, tobacco mosaic and potato virus "X" are most probably not transmitted by insects is questionable, even though insect vectors have not yet been demonstrated. Excepting bean, cucurbit and lettuce mosaics and tobacco ring spot, the author states "that though seed from infected plants often contains virus, the plants raised from such seed are healthy and virus free." For some reason the author has omitted any reference of the work carried out at Cheshunt and in Canada to the effect that tomato mosaic, under certain conditions, is transmitted by seed.

Chapter V on relationship between viruses and their insect vectors makes instructive reading for one who has not specialized in this field. The misuse of the term "incubation period" in the first edition in relation to separation of the two types of insect-transmitted viruses, has been rectified in the second. Virus strains, incubation and acquired immunity constitute Chapter VI. The use of the term immunity in this connection will not meet with general approval, as the author realizes, since many consider this phenomenon to be one of protection rather than immunity.

The role of serological reactions on identification of viruses constitutes Chapter VII, and since these reactions are group-specific, they constitute a very rapid means of identification. Chapter VIII discusses detailed methods of purification of tobacco mosaic, Potato "X" and "Y", tomato

bushy stunt and tobacco necrosis viruses, and also the use of the high-speed centrifuge in purification studies. Chapters X and XI describe the properties of purified virus preparations from standpoints of the chemical, physical and optical properties respectively, phases in which the author is particularly interested. These chapters should be of special interest and instruction to those virus workers who are not familiar with these specialized techniques.

In Chapter XI the inactivation of viruses is discussed under inhibitors, denaturation, heat and ageing, inactivation without loss of serological activity, drying and freezing, and hydrogen ion concentration. The size of virus particles is discussed in Chapter XII, under filterability, sedimentation velocities, viscosity and diffusion. There is also a section on X-rays and electron microscopy which was not included in the first edition. The effect of viruses on metabolism of host and the movement of viruses in the host is discussed in Chapter XIII. Movement is stated as being of two kinds, a slow movement in parenchymetous tissue via plasmodesmata and a rapid movement via the phloem.

The naming and grouping of viruses, their identification and bases of classification constitutes Chapter XIV. The author favours a classification based on the viruses themselves rather than on host relations. He suggests that plant protection and serological tests might be used as a basis in grouping of viruses to which some form of nomenclature could be fitted. However, the application of the serological technique is limited to certain types of viruses, and thus its use in respect to classification is in turn limited. Control of virus diseases in Chapter XV gives a good summary of control practices. The final Chapter discusses the origin and multiplication of viruses and raises the question as to whether viruses are living or non-living entities. It is pointed out that until the word life has been given an accurate definition, there is little chance of answering the above question, since the conclusion of various workers depends on their own viewpoint. This is a very intriguing Chapter with which to end a well written, instructive and most useful book on plant viruses.

G. H. BERKELEY.

FUNDAMENTALS OF SOIL SCIENCE. By C. E. Miller and L. M. Turk. Published by John Wiley & Sons, Inc., New York. $3.75.

This book was written for use as a college textbook, as a reference book for farmers and owners of farm lands and as an aid to anyone desiring information on soils and their culture. The book covers a wide field, a fact indicated by the following brief summary of the principal topics discussed: classification and development of soils, physical and chemical properties, soil moisture, organic matter, nutrient requirements for different crops, farm management practices, and the selection of soils for various crops.

This book is well prepared and clearly written. General principles of soil science are emphasized and explained in simple terms, omitting, so far

as possible technical discussions, particularly of debatable points. For this reason it is more suitable as a textbook for elementary rather than advanced courses in soils.

From a Canadian viewpoint the weakness of the book lies in the fact that where environmental factors affect the discussions the examples used refer to conditions in the United States. However, this weakness applies also to nearly all books on soils. Insofar as general principles are concerned Canadians will find this book a valuable and modern source of information. As might be expected from the reputation of the authors this is one of the better textbooks on the general principles of soil science.

A. LEAHEY.

CONSTITUENTS OF WHEAT AND WHEAT PRODUCTS. By C. H. Bailey. The Reinhold Publishing Corporation, 330 West Forty-Second Street, New York, U.S.A., 1944. 332 Pages, Price $6.50.

This is a monograph written by Dr. C. H. Bailey, Professor of Agricultural Biochemistry and Director of the Agricultural Experiment Station, the University of Minnesota, for the American Chemical Society Monograph Series. As the title indicates, it deals mainly with the descriptive biochemistry of wheat and wheat products, and continuously cites literature, both historic and up-to-date, on researches in wheat and wheat products. To the layman the presentation might be found laborious, but to the research worker and to persons wanting a ready reference to this subject, the book is invaluable.

The book is divided into 16 chapters, 7 of which are devoted to the proteins. The remainder give an account of researches on the starch, sugars, gums, pentosans, hemicelluloses, cellulose, lipids, phospholipids, sterols, minerals, the halogens, sulphur, selenium, acidity, wheat and flour pigments, and vitamins of wheat and wheat products. It is not a handbook of analytical methods, although it does refer in many cases to the methods employed, in order to present the data more clearly. Many comparative tables are given which should be very useful to those interested in obtaining ready information on any of the constituents found in wheat and its products. The book quickly dispels any ideas of simplicity of the constituents of wheat, both as to the amounts and properties, but it gives an appreciation of the vast amount of research which has been done on the subject, and brings that knowledge right up to the time of publication.

A. G. O. WHITESIDE

TERMITES (ISOPTERA) FROM THE AUSTRALIAN REGION. By Gerald F. Hill. 479 pp., 24 plates, 353 figs. Commonwealth of Australia, Council for Scientific and Industrial Research, Melbourne, 1942.

This work is a treatment, primarily systematic, of the termites occurring in Australia, New Guinea, and in the islands south of the equator

between 140° E. and 170° W. The author recognizes 193 species and 8 subspecies in the region and arranges them in 14 genera and 4 families; 32 of the species and 1 subgenus are described as new. The treatment is comprehensive; all of the known castes are described, often at some length, and a key to genera based on soldiers and keys to subgenera are included. The citations to the literature include references concerned with biology and economic importance, as well as those dealing with morphology and systematics, and what little is known of the biology of the various species is summarized in the text. Most of the figures are of cephalic and thoracic structures offered as an aid in identification. On the plates are reproduced 41 excellent photographs of the nests and work of termites. Of special interest to the general student are the photographs and the description of the nests of *Hamitermes meridionalis* (Frogg.). These nests may measure 12 by 10 by $3\frac{1}{2}$ feet and are always oriented so that the long axes are directed north and south. The volume includes a glossary and is well indexed.

The volume is a product of many years of study on the part of the author, who has arranged his material to show what is not known, as well as what is known, of the very interesting termite fauna of his region. Although the book is printed by a lithographic process, the format is pleasing and the figures are well reproduced.

W. J. Brown

BULLETINS FROM THE ONTARIO HORTICULTURAL STATION

Vineland Station, Ontario

The Ontario Department of Agriculture is to be congratulated on the quality of a number of bulletins recently issued from the Horticultural Station at Vineland, Ontario. These are farmers' bulletins published in a very attractive form, exceedingly well illustrated and well written. They should attract the attention of the fruit grower and retain his interest.

Orchard Soil Management. By E. F. Palmer and J. R. Van Haarlem. Bulletin 437—January, 1944.

This bulletin runs to 45 pages and contains a large number of illustrations, the cover illustration being in colour. Sources of organic matter, clean cultivation and cover crops, sod culture, and intermediate systems of soil management are discussed. References are given to other publications where further information may be secured. This bulletin itself, however, discusses the problem of orchard soil management in a manner which should be intelligible to the average fruit grower.

The Grape in Ontario. By C. B. Kelly. Bulletin 438—February, 1944.

The selection of varieties, planting, care of the young vineyard, trellising, pruning, training and tying, and vineyard soil management are discussed. There is also a good section on insects and diseases.

ORCHARD GRAFTING. By W. H. Upshall. Bulletin 439—April, 1944.

This bulletin gives a thorough discussion in simple language of the methods of grafting, and should prove exceptionally useful because of the excellent illustrations. Many of them are line drawings by Miss L. Heringa of the Department of Horticulture, O.A.C., Guelph. These drawings show the manner in which grafting should be done. The cover photograph is a very excellent illustration in colour of bridge grafting.

CURRANTS AND GOOSEBERRIES. By W. J. Strong. Bulletin 440—April, 1944.

This bulletin discusses pollination, varieties, propagation, soil and location, and the establishment and care of the plantation. More important diseases are discussed by Professor J. E. Howitt, Department of Botany, O.A.C., and chief insect pests by R. W. Thompson, Provincial Entomologist.